MOBILE EXPERTS

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Millimeter Wave 5G is necessary for capacity

Introduction

Four years ago, we expressed some doubts about mm-wave spectrum and its usefulness in a mobile network. But some tectonic changes in the market have changed our view. Despite huge difficulties and equally huge expense, we expect that leading operators will use mm-wave as an element of their mobile network. In fact, they have to.

This *INSIGHT* document illustrates how leading mobile operators will run out of capacity. We have been able to calculate the likely capacity/density that will be needed in rich urban markets, and we've examined the capability of the LTE network, including the impact of small cells and massive MIMO. Our conclusion: To reach their end goals, operators such as AT&T, Verizon, SKT, KT, NTT DoCoMo, and others cannot succeed without using mm-wave capacity to augment the existing bands.

Consumer Market Shift

To begin, let's look at the demand for mobile data. Over the past 20 years, the market has been clearly segmented into "mobile data" and "fixed broadband". Those distinctions are quickly disappearing, and we believe that within 3 years, these two segments will be viewed as the same market.

In the US market, the transition has already begun. T-Mobile USA offers unlimited Netflix over their network. AT&T is launching a direct-to-consumer streaming service for HBO and other Time Warner content. And the cable companies are suffering from 'cord cutting' which is reducing their subscriber numbers by hundreds of thousands per quarter. Comcast and Charter are responding with MVNO offerings, in an attempt to hide their problems with 'cord cutting' by adding similar numbers of mobile users.

From our unbiased vantage point, it appears that Mobile is winning, and Cable is losing. The cable operators have a few hundred thousand MVNO customers, but they're paying exorbitant fees to Verizon for LTE roaming, and they are surely losing money so far. More importantly, the 200-400,000 subscribers that they have are not new customers; almost all of these are existing Comcast or Charter cable subscribers that agreed to consolidate by using a wireless service also. That means that, despite a good story about growth for the MVNO, US Cable operators will lose about 5 million customers in 2018. Churn is not measured only within a segment now; churn is real between Cable and Mobile.

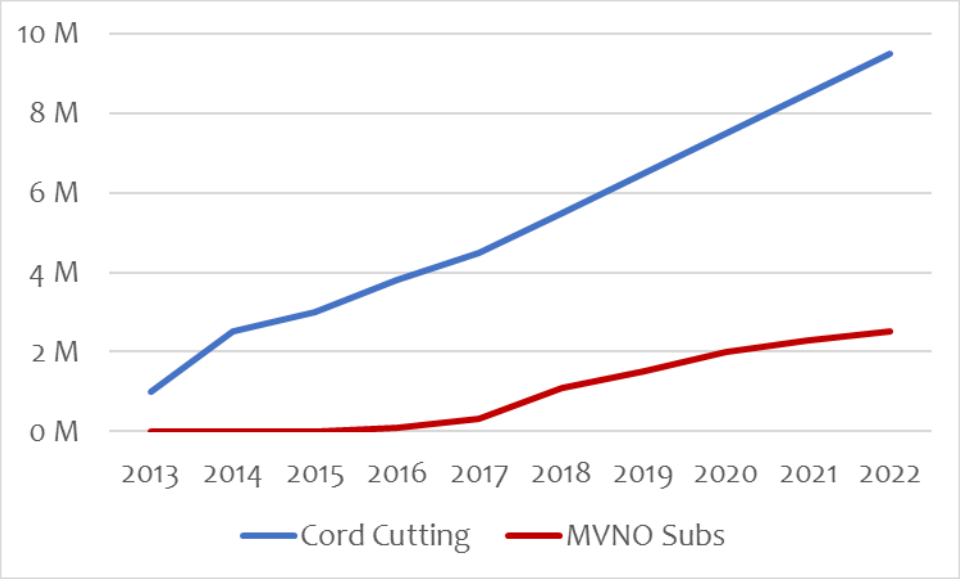

Figure 1: Cord Cutting doesn't balance with new MVNO subscribers

Sources: Mobile Experts

Based on the current trend, we expect the cord cutting to get even deeper. Roughly 4.5 million subscribers dropped cable TV in 2017, and 5 million will drop this year. During 2019 and 2020, let's assume that another 15 million households will drop cable TV. Over the next two years, even an optimistic forecast for Cable MVNO offerings suggests about 3 million users will sign up for wireless services. (There is some lack of clarity about whether an MVNO subscriber is as lucrative as a pay-TV subscriber. We estimate that the average pay-TV bundle costs about $120 per month, but MVNO subscribers pay $40 per month, max.) Wall street will not ignore this obvious disparity much longer, and the stock prices of Comcast, Charter, and other major cable operators will start to drop.

When it becomes difficult for Comcast and Charter to raise money for a major CBRS buildout, or buying their own spectrum, or other major maneuvers, we don't think they will have the support of Wall Street.

Mobile Traffic Demand

We've just told the story of the fixed broadband market dying, or converging with the mobile market, because the high level of cord cutting is proof that the demand for mobile data will continue to soar. If mobile data were only used for maps and short

Facebook videos, then usage would be likely to level off at 10-15 GB per month, and the market would enter an equilibrium phase. That is not happening. Instead, the mobile market will gobble up the fixed broadband market, where households consume 180-200 GB per month. The ceiling on mobile data usage has now shot up to a new level.

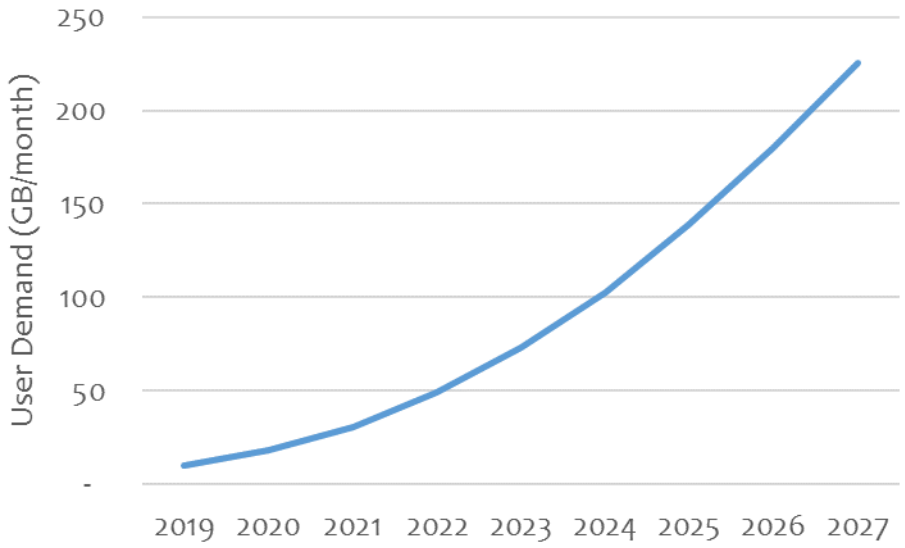

Figure 2: Expected change in user demand on mobile networks

Sources: Mobile Experts

Demand vs Capacity: T-Mobile and Sprint

Based on this ongoing demand growth profile, the US mobile operators will quickly outstrip the LTE capacity that they have available. The analysis shown below examines the combined T-Mobile/Sprint network (referred to as 'New T-Mobile'). Assuming that this merger closes without changes, New T-Mobile will have more spectrum than any other operator, with roughly 180 MHz in the 600-2300 MHz bands and 160 MHz in the 2.5 GHz band.

In this scenario, we assume that New T-Mobile will gain market share, settling out at 35% share. With strong ongoing demand growth, the LTE baseline capacity (using all bands between 600 MHz and 2.3 GHz) will satisfy demand through 2024, because New T-Mobile can add capacity using LAA and CBRS bands. After 2024, mm-wave capacity will be necessary to continue taking over the broadband market.

The below chart assumes that mm-wave capability is added to urban sites only through the 2027 timeframe… adding enough capacity in the hottest hotspots without attempting to blanket the entire country in mm-wave services. In this scenario (with 100 MHz of 5G spectrum at 3.7 GHz), the mm-wave network can do an effective job through about 2027. After that point in time, we cannot predict what will happen, because New T-Mobile may not have enough mm-wave spectrum to keep growing. Possibly, demand growth will slow down because users have converted from fixed to mobile. If demand growth continues beyond 2027, additional low-band or mid-band spectrum could be required to enable suburban areas to have adequate capacity.

The alternative to deploying mm-wave on available small cell sites: Finding thousands of small cell sites on short notice. Can New T-Mobile add 10,000 to 20,000 small cell sites per year by 2021? We think that mm-wave on the existing small cell sites is a far more practical option.

Our conclusion: Even with Sprint's spectrum, T-Mobile needs to bid for big mm-wave blocks for urban centers. They can ignore mm-wave spectrum in rural areas, but they will need it in New York, San Francisco, Chicago, and other key cities.

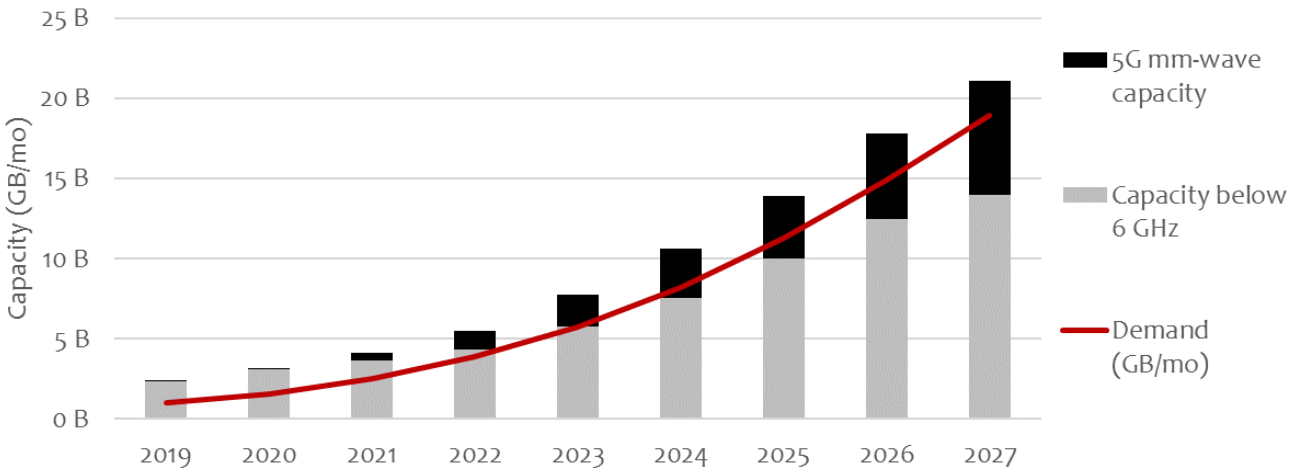

Figure 3: Demand vs. Capacity for Combined T-Mobile/Sprint Network

Sources: Mobile Experts

Demand vs Capacity: Verizon and AT&T

In the cases of AT&T and Verizon (as well as operators in Korea, Japan, Finland, and a few other countries) the situation is more immediate. Our analysis indicates that AT&T and Verizon will add capacity using Small Cells, LAA, and CBRS in the near term to keep up with demand. By aggressively adding small cells that include all possible bands below 6 GHz, Verizon and AT&T can add significant capacity but will not quite keep up with demand growth. The addition of the 3.7 GHz band will bring a bit more capacity in 2023-2026, but even a rapid deployment will barely keep up with capacity nationwide.

Verizon, AT&T, SKT, NTT DoCoMo, and other operators have already been adding small cells as rapidly as the lawyers can write deals. The limitation here is not exactly technical, it's a challenge to equip new sites quickly enough to keep up with demand, especially with small cells that use skinny bands below 6 GHz.

This means that hotspots in the cities will experience overloading throughout the 2022-2026 timeframe….mm-wave capacity will become absolutely necessary for locations such as subway platforms, stadiums, and other crowded spots where the traffic peaks, as well as dense urban housing centers where fixed broadband traffic is heavy today. Millimeter-wave base stations will be indispensable for mobile capacity starting in 3 years. A detailed and complete review of the Verizon/AT&T/Korean/European scenarios will be published in our upcoming 5G Broadband Business Case (MEXP-5GBB-18-BC) report.

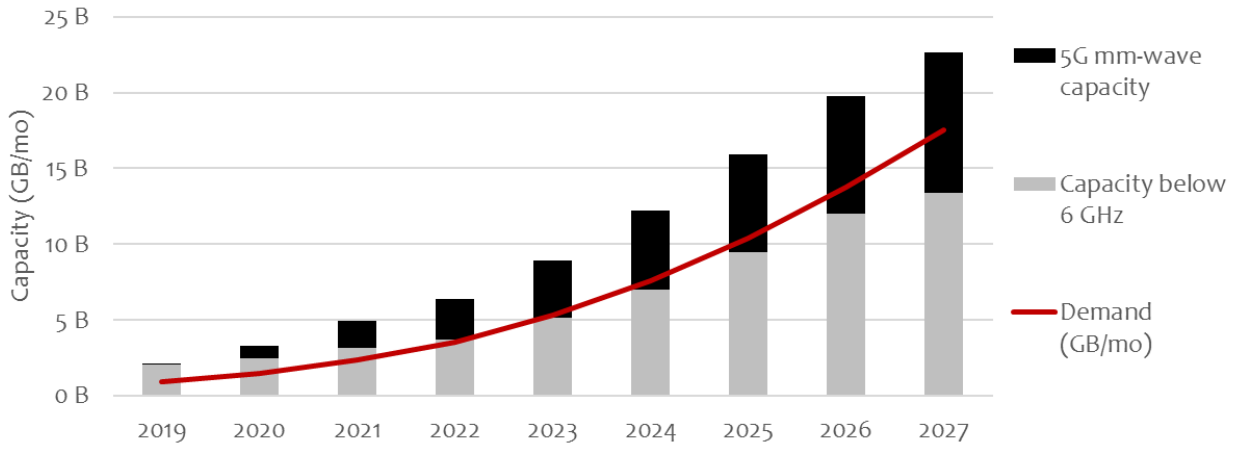

Figure 4: Demand vs. Capacity for Verizon (with CBRS, LAA, 3.7 GHz, and mm-wave)

Sources: Mobile Experts

Conclusions

We draw a few conclusions out of the basic supply vs. demand analysis:

- Bidding for the mm-wave spectrum will be aggressive in the upcoming auction.
- The forecast for 5G mm-wave radios will be higher than previous predictions, because 5G mm-wave has become critical to mobile networks, not just for fixed wireless.
- CBRS and 3.7 GHz are critical bands and will also sell for high prices in anticipated FCC auctions.
- Site acquisition for new small cell sites will be an important challenge. Any difficulties in site acquisition will drive stronger use of mm-wave on existing small cell sites.
- Innovation in handsets and mobile hotspots will be important, as offloading LTE traffic onto a mm-wave network will not be easy. Subsidies for hotspots and special handsets may be necessary, at least for heavy users.